SCANLAN

Investigation of a Highway Bridge

Civil Engineering

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INVESTIGATION OF A HIGHWAY BRIDGE

BY

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THESIS

FOR THE

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IN

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I recommend that the thesis prepared under my supervision by JACK ADDISON SCANLAN entitled Investigation of a Highway Bridge be approved as fulfilling this part of the requirements for the degree of Bachelor of Science in Civil Engineering.

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Recommendation approved:

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An Investigation of a Highway Bridge

Introduction.

At the point where the tracks of the Illinois Traction System cross the North Fork of the Vermillion River at Danville, Illinois, there exists a seven panel pin connected through Pratt truss. This bridge has been in use for a number of years and is used to carry the passenger and freight cars of the electric railroad, as well as the ordinary highway traffic, at this point. There are several reasons why this bridge seems to need investigation in order to determine whether or not it can carry these loads with safety.

The bridge is located in such a position that the tracks must

be sharply curved at one end, and run along one side of the roadway the remaining length of the bridge. The entire floor space is covered with plank flooring, and when there are no cars on the bridge it serves the purpose of an ordinary highway bridge. The general appearance of the bridge, and this is confirmed in the investigation, indicates that the structure was not designed for interurban traffic, but that additional stringers were placed in position and tracks were laid for this purpose. The whole structure is very light and not rigid in its construction, and the abutments are in no condition to stand the strain put upon them.

One abutment, which is under the curved end of the track, is split vertically from top to bottom and shows a differential horizontal movement of five inches and a

vertical movement of two inches between the two parts. To take care of this movement of the abutment, the pedestal has been uncoupled from the end floor beam to allow the trusses to spread and a two-inch plank has been inserted as a shim to raise the sunken pedestal to its proper elevation. The plank rests between the pedestal and the masonry plate and no anchor bolts are used to hold the parts in place.

The other three pedestals are in very poor condition as they are badly rusted. Other points of bad detail are present and will be taken up and investigated in their respective places.

The investigation of the structure will be made in accordance with the following outline:-

(See Next Page)

Outline

Part I.

Introduction

Description of the Bridge

(a) General Dimensions

(b) Weights

Part II.

Loadings Used.

(a) Line Load

(b) Dead Load

(c) Wind Load

(d) Centrifugal Load.

Stresses in Trusses

(a) With Impact

(b) Without Impact

Part III.

Investigation of Efficiencies of Parts.

(a) Main Members

(b) Detail

Part IV

Recommendations.

Description of the Bridge.

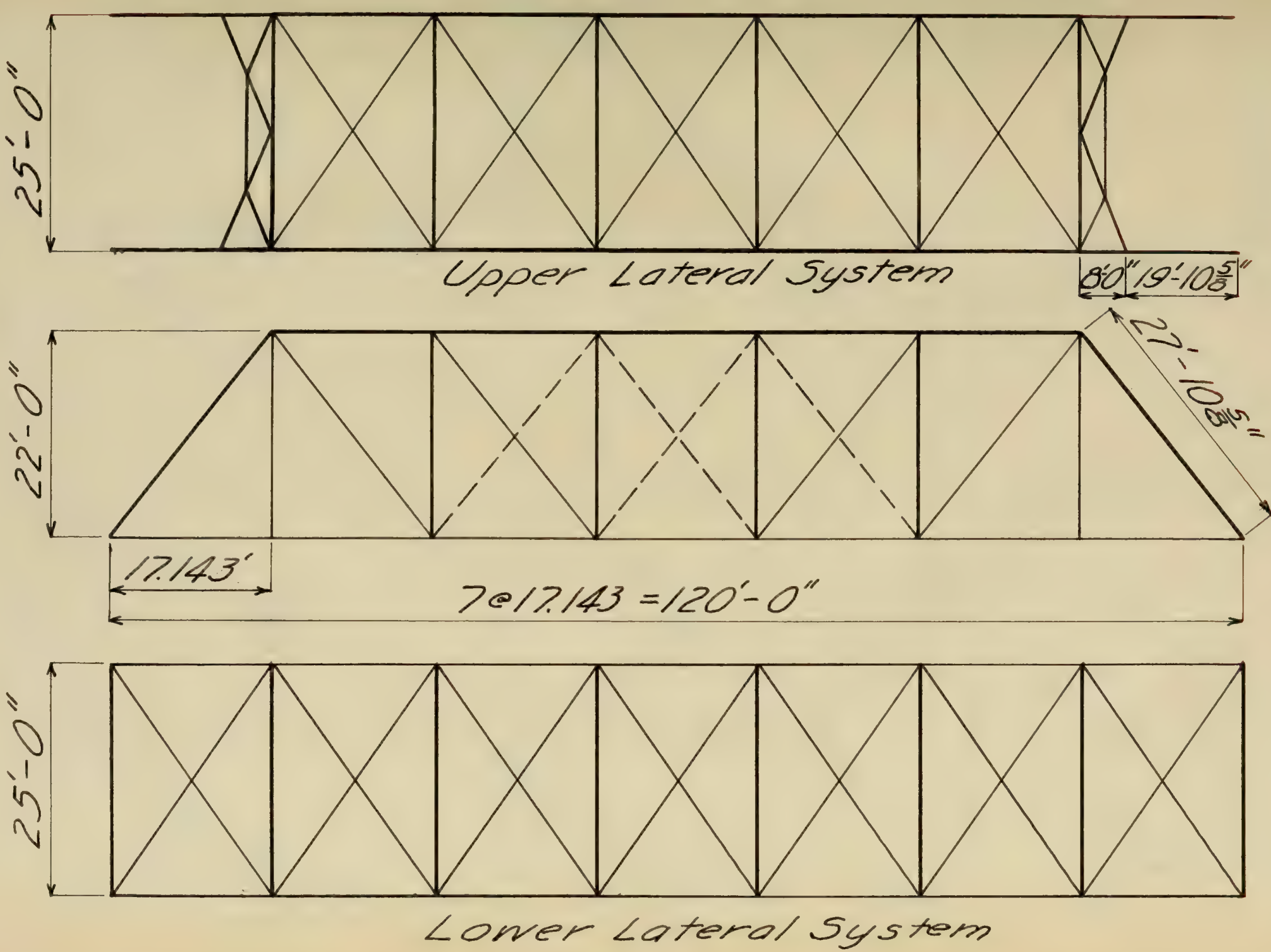
The bridge is a seven-panel, pin connected, through Pratt truss, having a span of 120'-0" between end pins. The trusses are spaced 25'-0" C to C giving a clear roadway of 24'-0". The height C to C pins is 22'-0"

The floor of the entire bridge is covered with 3 inch plank, making a floor for highway traffic. At an average distance of 7'-0" from the right truss a single track for interurban traffic has been placed, by adding additional stringers to the floor system. This track is sharply curved at the south end of the bridge for a distance of about 40 feet.

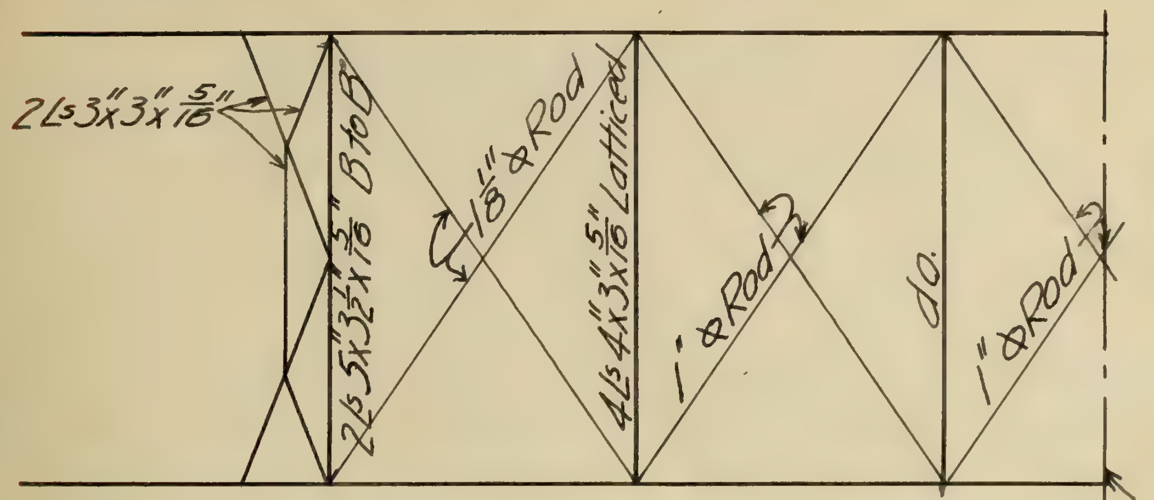
There is also a sidewalk along the outside of the left truss but this will probably never be used, owing to the small amount of foot traffic.

The general description is shown in the following sketches.

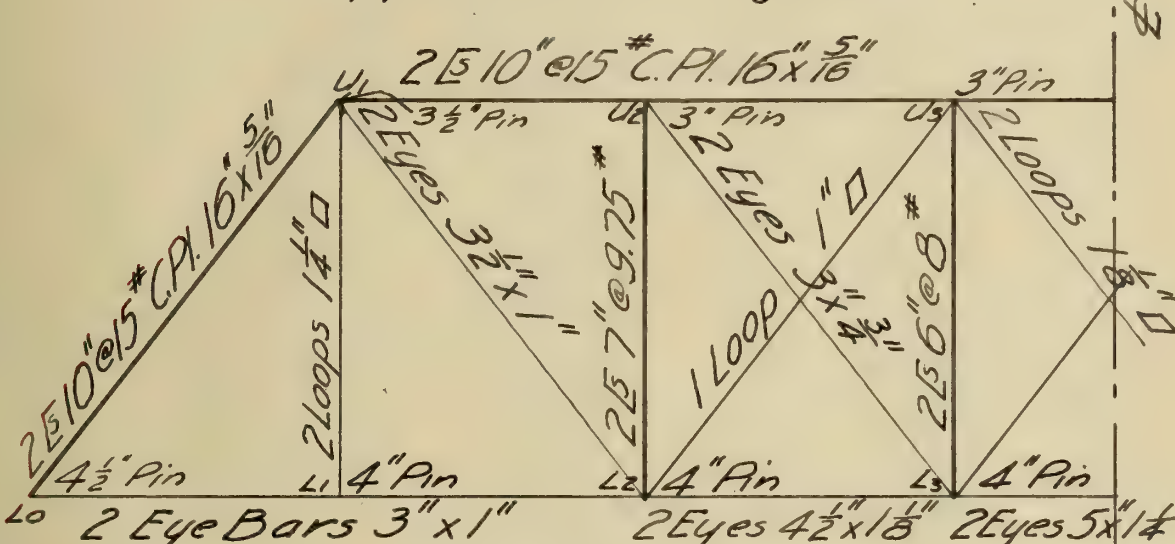
GENERAL DEMENSIONS OF TRUSSES



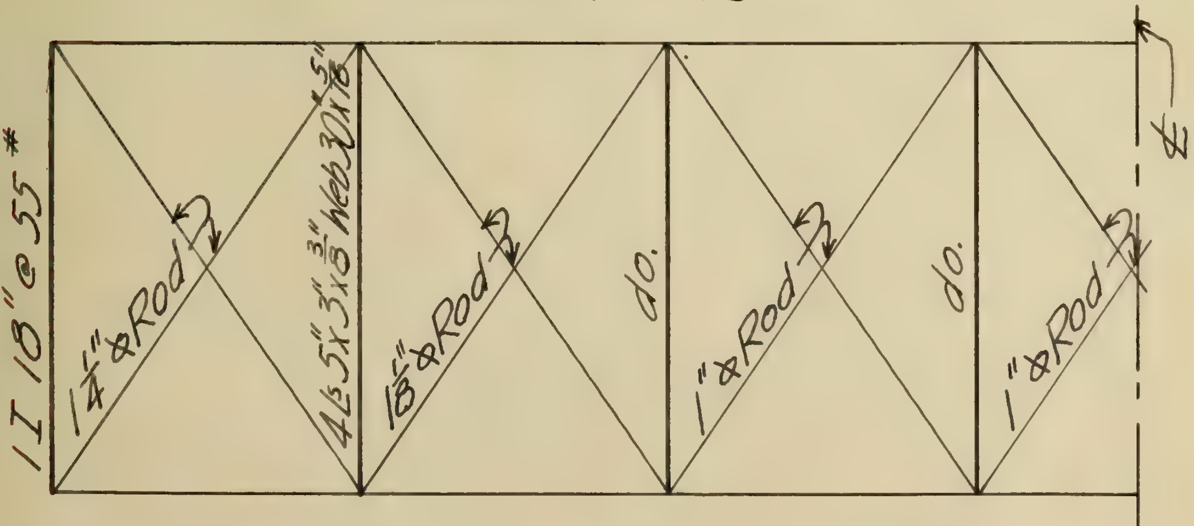
GENERAL DESCRIPTION OF MEMBERS



Upper Lateral System



Main Truss



Lower Lateral System

TABLE OF WEIGHTS

— COMPILED FROM —

DETAILED MEASUREMENTS OF BRIDGE

—SUMMARY—

Ref. No	Members or Parts	Weight Main	Weight Detail	Weight Total	Percent Detail.
1	End Posts	5005	735	5740	12.8
2	Top Chord	8020	1270	9290	13.7
3	Bottom Chord	8595	865	9460	9.1
4	Interm. Post.	2950	3270	6220	52.5
5	Main Diagonals	4370	280	4650	6.0
6	Counters	1340	280	1620	17.3
7	Hip Verticals	75	75	880	8.3
8	Floor Beams	4985	4100	9085	45.1
9	Joists	22530	0	22530	0
10	Top Lat. Struts	850	585	1435	40.8
11	Knee Braces	795	95	880	10.8
12	Top Lat. Rods	1140	230	1370	16.7
13	Bottom Lat. Rods	1790	95	1885	4.9
14	Portals	2310	195	2505	7.8
15	Pins and Nuts	570	990	1560	63.5
16	Pedestals	0	160	160	100.0
17	Rollers	0	400	400	100.0
18	Sidewalk Bracket	0	2700	2700	100.0
19	Sidewalk Joists	0	3390	3390	100.0
20	Track	0	0	48000	—
21	Hand Rail	0	700	700	100.0
22	Flooring	0	0	44900	—
	Totals	65325	20415	179340	23.8

Part II

Loadings Used

In this investigation the main object will be to show whether or not the bridge is strong enough to carry the present interurban traffic. Consequently the following loadings are chosen, which are very nearly the actual conditions as they exist.

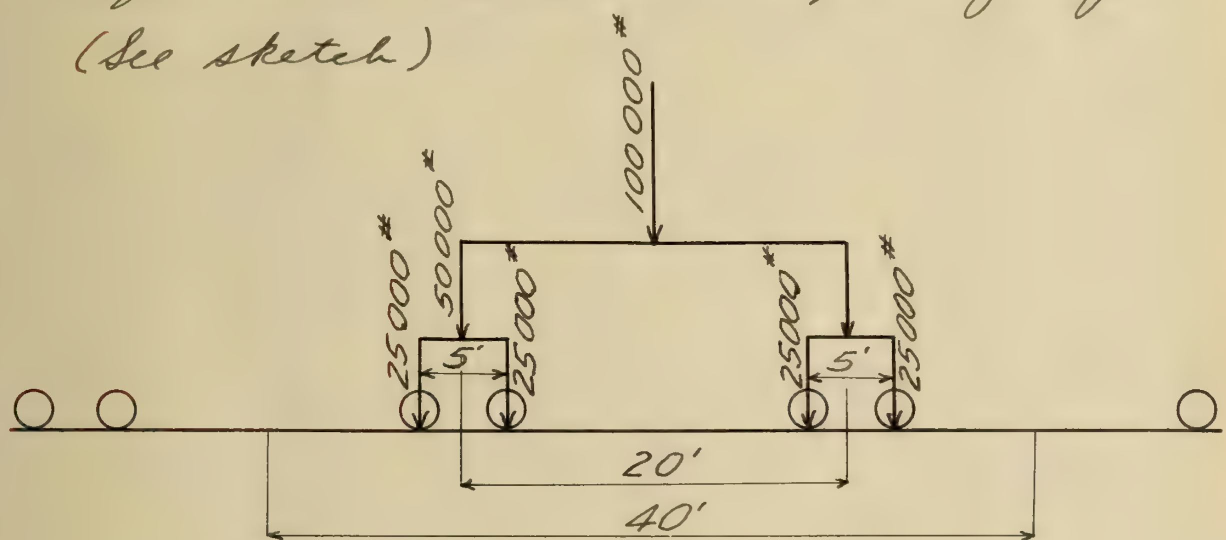
Two conditions are assumed,- one in which impact is considered and one in which impact is neglected. This is done because the bridge is obviously weak, and it was thought the bridge could be used if the cars traveled slowly enough to avoid impact stresses.

In investigating for highway traffic only, a live load of 86 lbs. per sq. ft. is used in accordance with Ostrup's specifications. (Art 60.)

Loadings Used.

Live Load.

In accordance with Ostrup's specifications, the live load used will consist of a continuous train of cars, each 40 feet long and weighing 100 000 lbs, distributed over two trucks 20 feet centers, each truck composed of two pairs of wheels 5 feet C to C axles and 5 feet guage (See sketch)



On account of the fact that there is only a remote chance of there ever being any live load on the floor of the bridge, while the bridge is fully loaded with cars, the floor load

for highway traffic as required by Ostrup's specifications will be neglected. In the investigation of the floor joists a live floor load of 100 #/□' will be used.

Dead Load.

The dead load used will be the actual weight of the bridge, flooring, and track, as computed from the measurements taken at the bridge. The weights of the end floorbeams and pedestals will be subtracted from the total weight of the bridge. As computed this gives a dead panel load of 12,700 lbs but to allow for any possible excess a panel load of 13000 lbs will be used.

Wind Load - Upper Chord

There will be assumed a moving load of 150 # per foot of truss acting on the upper chord. This is equivalent to a panel load of 2600 lbs.

Wind Load – Lower Chord.

There will be assumed a moving load of 250# per foot of truss acting on the lower chord. This is equivalent to a panel load of 4300 lbs.

Centrifugal Load.

There will be assumed a moving load equal to 10% of the live load on the truss, acting on the train at a distance of 5 feet above the base of rail. This is equivalent to a panel load of 4300 lbs.

Impact.

Where impact is considered, it shall be equal to $S\left(\frac{200}{300+L}\right)$, where

S = live load stress, moment or shear.

L = length of the loaded section in ft.

Computations will be made in which impact is considered, as well as similar ones where impact is not considered.

Part II

Stresses in Trusses.

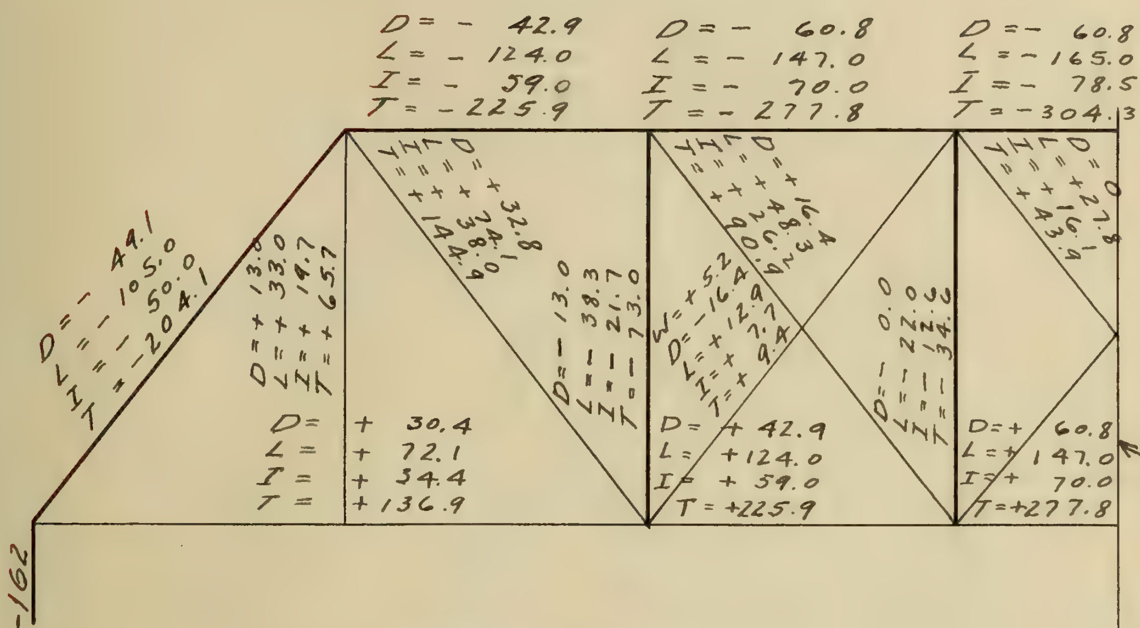
The maximum stresses will be shown separately for each truss, and under two conditions, (a) when impact is considered and (b) when impact is neglected. There are no reversals of stresses in any of the main members, therefore no minimum stresses are shown.

The methods used in calculating the stresses will not be shown. These may be found in any treatise on elementary bridge analysis.

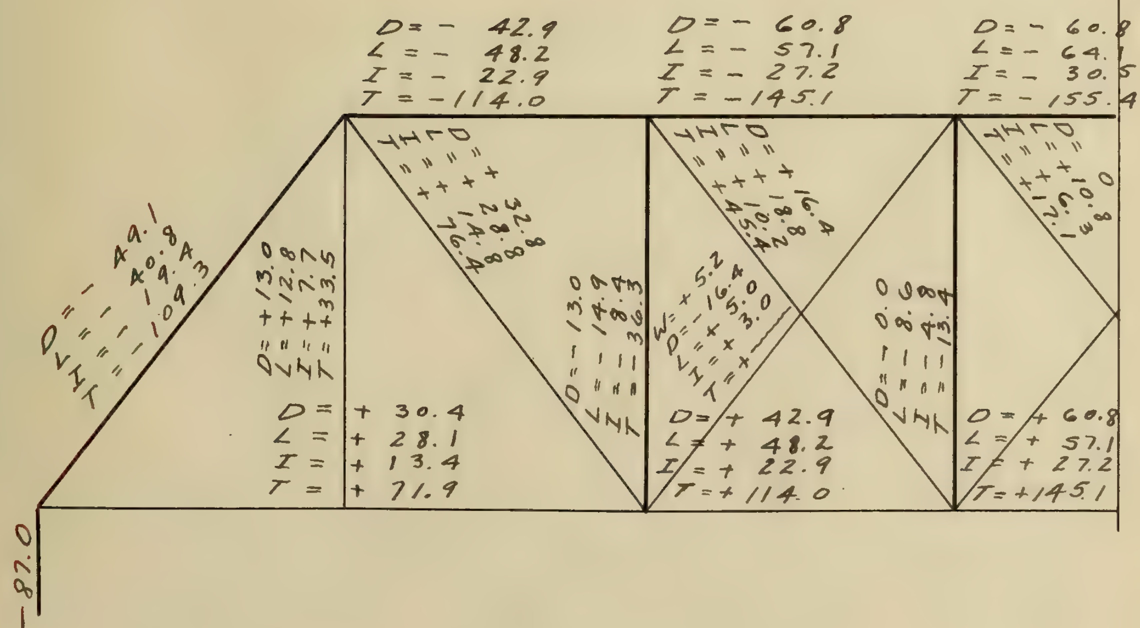
The symbol (+) denotes tension in a member and the symbol (−) denotes compression. (D) denotes dead load stress, (L) live load stress, (I) impact stress, (W) wind stress, and (T) the total stress in any member.

Stresses In Trusses With Impact

Right Truss



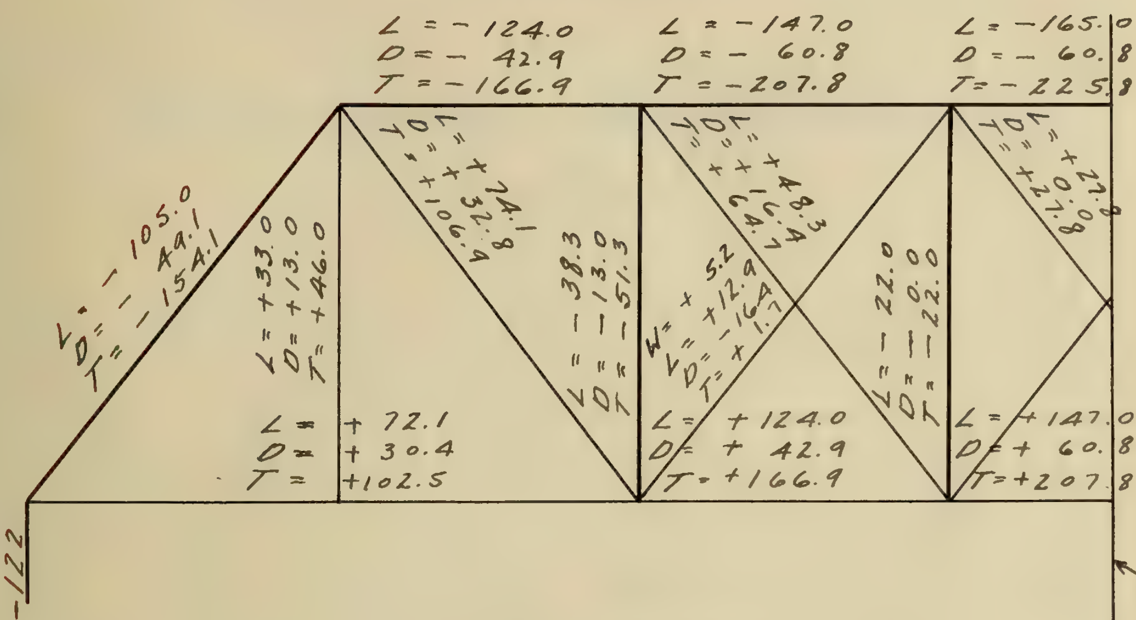
Left Truss



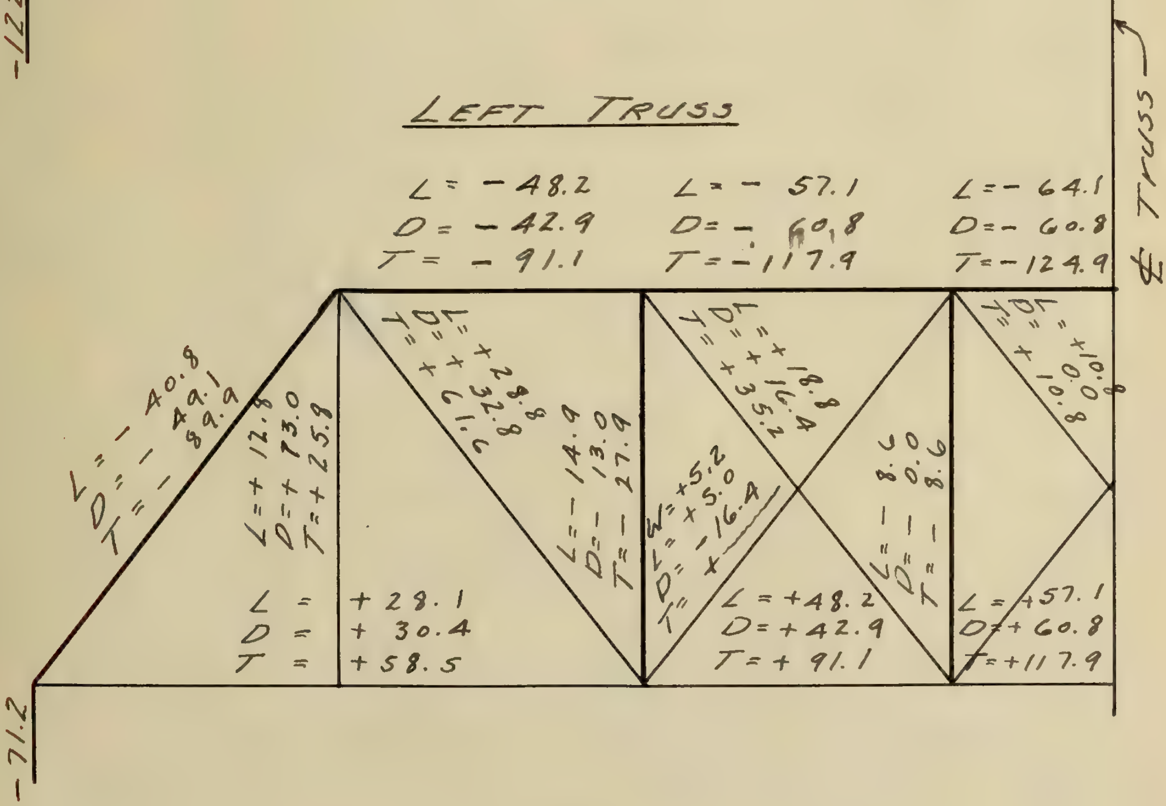
STRESSES IN TRUSSES

WITHOUT IMPACT

RIGHT TRUSS



LEFT TRUSS



Part III.

Investigation of Efficiencies of Parts.

In this investigation, the efficiencies of each truss will be worked out separately, due to the different stresses in the respective trusses. The reasons will be more apparent when the recommendations are given.

The West truss, which is the one nearest the railway tracks, will be designated as the "Right" truss while the other will be designated as the "Left" truss.

Efficiencies "With Impact" will also be distinguished from those "Without Impact"

Part III

Efficiencies of Members In Compression

Upper Chord.

The Upper Chord is composed throughout of 2 [s 10" @ 15.00# spaced 10" back to back with a cover plate 16" × $\frac{5}{16}$" on the top, and single lattice bars 2" × $\frac{5}{16}$" on the bottom.

$l = 17.143'$
$r = 3.92''$
$\frac{l}{r} = 52.5$
$A = 13.92 \square''$

Pins are placed on the ℄ of the [s

The allowable unit stress equals

$16000 - 70\frac{l}{r} = 9320$ #/□"

The efficiencies of the members of the top chord are as follows.-

Right Truss

Member	Maximum Stress		Efficiency	
	With Imp.	Without Imp.	With Imp.	Without Imp.
$U_1 U_2$	− 225.9	− 166.9	57.5 %	77.9 %
$U_2 U_3$	− 277.8	− 207.8	46.7 %	62.6 %
$U_3 U_4$	− 304.3	− 225.8	42.9 %	57.5 %

Left Truss

Member	Maximum Stress		Efficiency	
	With Imp.	Without Imp.	With Imp.	Without Imp.
$U_1 U_2$	-114.0	-91.1	114 %	143 %
$U_2 U_3$	-145.1	-117.9	90 %	110 %
$U_3 U_4$	-155.4	-124.9	84 %	104 %

End Posts

The End Posts are made up of the same section as the top chord. The length is 28'-0" making $\frac{l}{r} = 86$.

$16000 - 70\frac{l}{r} = 10000$ #/□" all stress.

The efficiencies are as follows.-

Right Truss

Maximum Stress		Efficiency	
With Imp.	Without Imp.	With Imp.	Without Imp.
-204.1	-154.1	68.1 %	90.5 %

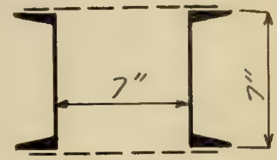
Left Truss

Maximum Stress		Efficiency	
With Imp.	Without Imp.	With Imp.	Without Imp.
-109.3	-89.9	127 %	155 %

The lacing bars and batten plates are sufficient to meet the requirements of the specifications.

Intermediate Posts U_2L_2 and U_3L_3

The post U_2L_2 is made up of 2 [s 7" @ 9.75# spaced 7" back to back with single lacing 2" x 5/16" on each side

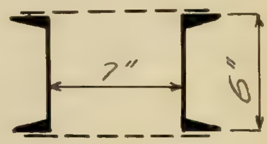


The allowable stress is

$16000 - 70\frac{l}{r} = 8950$ #/□"

$l = 22'-0"$
$r = 2.72"$
$\frac{l}{r} = 97$
$A = 5.70$ □"

U_3L_3 is composed of 2 [s 6" @ 8.00# spaced 7" back to back. with single lacing 2" x 5/16" on each side.



The allowable stress is

$16000 - 70\frac{l}{r} = 8100$ #/□"

$l = 22'-0"$
$r = 2.34"$
$\frac{l}{r} = 113$
$A = 4.76$ □"

The lacing and batten plates are sufficient to meet the requirements of the specifications.

The efficiencies are as follows.-

Right Truss

Member	Maximum Stress		Efficency	
	With Imp.	Without Imp.	With Imp.	Without Imp.
U_2L_2	-72.0	-51.3	78.0	108.0
U_3L_3	-42.8	-30.2	111.2	157.5

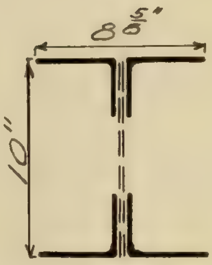
Left Truss.

Member	Maximum Stress		Efficiency	
	With Imp.	Without Imp.	With Imp.	Without Imp
$U_2 L_2$	-36.3	-27.9	141 %	183 %
$U_3 U$	-13.4	- 8.6	356 %	566 %

The thickness of the web of the Ls in $U_3 L_3$ is less than 1/4 inch as required by the specifications. (Art. 87)

Lateral Struts

The top lateral struts are all composed of 4 Ls 4"x 3"x 5/16" with double lacing. The 3" legs are back to back and back to back of the 4" legs is 10."



$l = 25'-0"$
$r = 2.02$ in
$\frac{l}{r} = 149$
$A = 8.36$ □"

The allowable stress is

$(16000 - 70\frac{l}{r})1.25 = 6880$ #/□"

The efficiencies are as follows.

Member	Maximum Stress	Efficiency
$U_2 U_2'$	-5.2	1100 %
$U_3 U_3'$	-3.1	1800 %

($U_1 U_1'$ is taken up as part of the portal)

Efficiencies of Members In Tension

Lower Chord.

The Lower Chord is made up of two lines of Eye Bars of standard design as given in Cambria Handbook, Hence the design is not investigated

The allowable stress is 16000 #/□"

The efficiencies are as follows

Right Truss

Member	Sq. In Area	Maximum Stress With Imp.	Maximum Stress Without Imp.	Efficiency With Imp.	Efficiency Without Imp.
$L_0 L_2$	6.00	+136.9	+102.5	70.2 %	93.6 %
$L_2 L_3$	10.12	+255.9	+166.9	72.0 %	97.3 %
$L_3 L_4$	12.50	+277.8	+207.8	72.0 %	96.2 %

Left Truss

Member	Area Sq. In.	Maximum Stress With Imp.	Maximum Stress Without Imp.	Efficiency With Imp.	Efficiency Without Imp.
$L_0 L_2$	6.00	+71.9	+ 58.5	133 %	164 %
$L_2 L_3$	10.12	+114.0	+ 91.1	142 %	177 %
$L_3 L_4$	12.50	+145.1	+117.9	138 %	170 %

Main Diagonals

The Main Diagonals are all made up of two lines of Eye Bars of standard design as given in Cambria Handbook, Hence the design is not investigated.

The allowable stress is 16000 #/□"

The efficiencies are as follows

Right Truss.

Member	Area Sq. In.	Maximum Stress		Efficiency	
		With Imp.	Without Imp.	With Imp.	Without Imp.
U_1L_2	7.00	+144.9	+106.9	77.5 %	105.0 %
U_2L_3	4.50	+ 90.9	+ 64.7	77.9 %	111.2 %

Left Truss

Member	Area Sq. In.	Maximum Stress		Efficiency	
		With Imp.	Without Imp.	With Imp.	Without Imp.
U_2L_2	7.00	+ 76.4	+ 61.6	147 %	182 %
U_2L_3	4.50	+ 45.4	+ 35.2	159 %	204 %

Counters.

The counters are all composed of square loop bars with turnbuckles. In every case the threads are upset so the net section is greater than the section of the bar. Hence the threads are not investigated for efficiency.

The allowable stress is 16000 #/□"

The efficiencies are as follows

(See Next Page)

Right Truss

Member	Area Sq. In.	Maximum Stress With Imp.	Maximum Stress Without Imp.	Efficiency With Imp.	Efficiency Without Imp.
$U_3 L_4$	2.54	+54.1	+38.2	93.6%	133 %
$U_4 L_5$	1.00	+1.7	+ 1.7	212.2%	1110 %

Left Truss

Member	Area Sq. In.	Maximum Stress With Imp.	Maximum Stress Without Imp.	Efficiency With Imp.	Efficiency Without Imp.
$U_3 L_4$	2.54	+17.1	+10.8	238%	376 %
$U_4 L_5$	1.00	(Does Not	Act For	Left Truss)	

Hip Verticals.

The Hip Verticals are composed of 2 square loop bars without turn-buckles. They are connected by 4½" pins to plates 8"x½" which support the floor beam. The loop bars are the smaller section and govern the efficiency.

The allowable stress is 16000 #/□"

The efficiencies are as follows.

Right Truss

Area Sq. In	Maximum Stress With Imp.	Maximum Stress Without Imp.	Efficiency With Imp.	Efficiency Without Imp.
3.12	+65.7	+46.0	76.0 %	108.0 %

Left Truss

Area Sq. In	Maximum Stress With Imp.	Maximum Stress Without Imp.	Efficiency With Imp.	Efficiency Without Imp.
3.12	+ 33.5	+ 25.8	149 %	193 %

Summary of Efficiencies

Right Truss

Section	Member	Eff. With Imp.	Eff. Without Imp.
Top Chord.	$U_1 U_2$	57.5 %	77.9 %
	$U_2 U_3$	46.7	62.6
	$U_3 U_4$	42.9	57.5
End Post	$L_0 U_1$	68.1	90.5
Int. Post	$U_2 L_2$	78.0	109.2
	$U_3 L_3$	111.2	157.5
Lower Chord.	$L_0 L_2$	70.2	93.6
	$L_2 L_3$	72.0	97.3
	$L_3 L_4$	72.0	96.2
Diagonals	$U_1 L_2$	77.5	105.0
	$U_2 L_3$	77.9	111.2
Counters	$U_3 L_4$	93.6	133.0
	$L_2 U_3$	212.2	1110.0
	Lateral System.		
Lower Chord Bracing	$L_0 L_1'$	66.4	—
	$L_1 L_2'$	79.5	—
	$L_2 L_3'$	94.0	—
	$L_3 L_4'$	129.0	—
Top Chord Bracing	$U_1 U_2'$	254.0	—
	$U_2 U_3'$	338.0	—
	$U_3 U_4'$	650.0	—
Lateral struts	$U_2 U_2'$	1100.0	—
	$U_3 U_3'$	1800.0	—

(con)

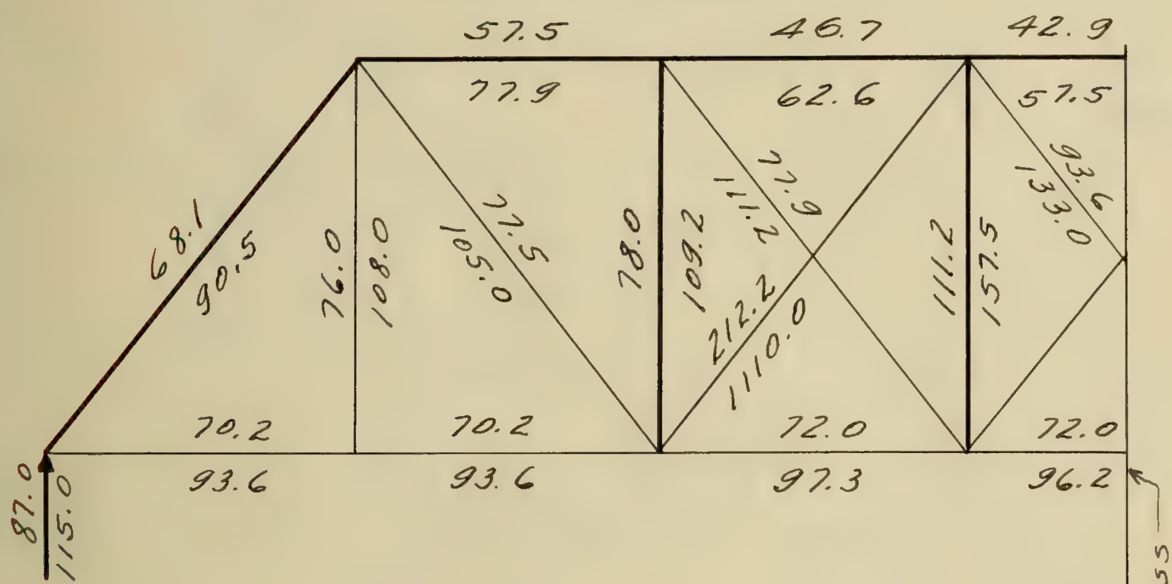
Left Truss

Section	Member	Eff. With Imp.	Eff. Without Imp.
Top Chord	$U_1 U_2$	114 %	143 %
	$U_2 U_3$	90 %	110 %
	$U_3 U_4$	84 %	104 %
End Post	$L_0 U_1$	127 %	155 %
Int. Post	$U_2 L_2$	141 %	183 %
	$U_3 L_3$	356 %	566 %
Lower Chord	$L_0 L_2$	133 %	164 %
	$L_2 L_3$	142 %	177 %
	$L_3 L_4$	138 %	170 %
Diagonals	$U_1 L_2$	147 %	182 %
	$U_2 L_3$	159 %	204 %
Counters	$U_3 L_4$	238 %	376 %
	$L_2 U_3$	∞ %	∞ %

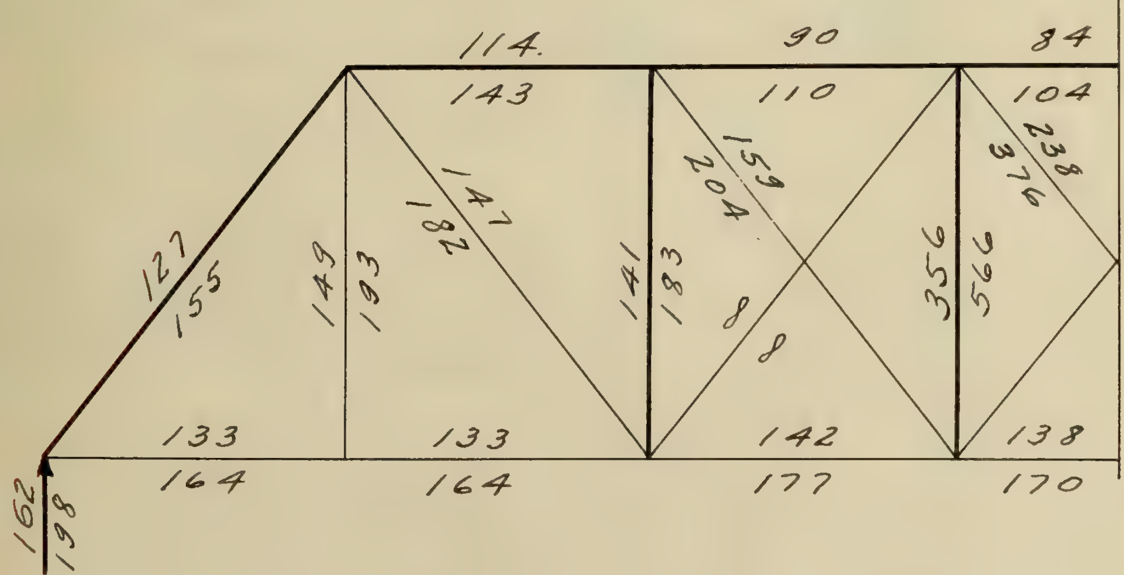
EFFICIENCIES OF MEMBERS
FOR
TRAIN LOADS

Note:- Values Above Lines Are With Impact
Values Below Lines Are Without Impact.

RIGHT TRUSS

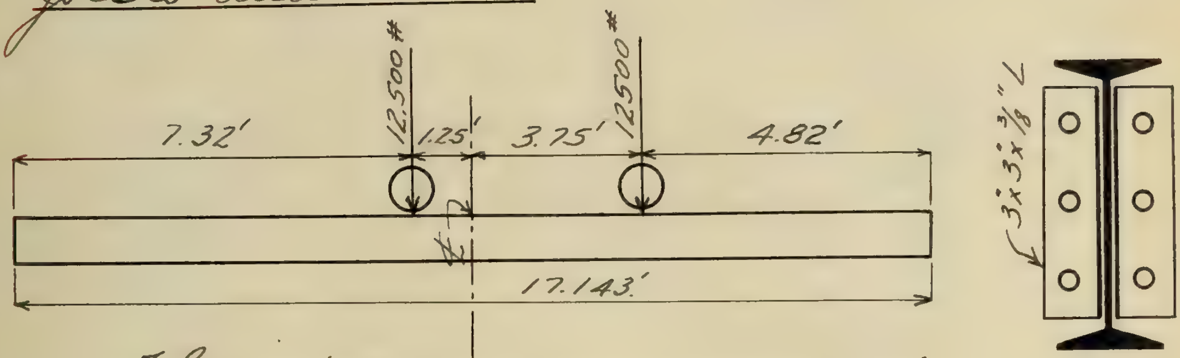


LEFT TRUSS



Efficiencies of Details.

Joists Under Track.



The joists are composed of 15" @ 42# I Beams placed directly under the rails

15" @ 42# I
$A = 12.48 \text{ in}^2$
$\frac{I}{C} = 58.9 \text{ in}^3$
$l = 17.143'$

Dead Load is the weight of one I Beam plus 200 lbs per foot of track. Live load is shown above by the sketch.

The efficiencies in bending are as follows

Max. Bending Mo.		Extreme Fibre Str.		Efficiency	
With Imp.	Without Imp.	With Imp.	Without Imp.	With Imp	Without Imp
1 652 000	1054 000	28100	17900	57.2	84.9

The efficiency in shear is as follows

Maximum Shear		Max. Unit Stress		Efficiency	
With Imp	Without Imp.	With Imp.	Without Imp.	With Imp	Without Imp
37.0	23.5	2960	1880	340	530

The connection to the floorbeam is made by means of 2 Ls 3"x3"x3/8". 6 field rivets are used in the web of the floorbeam

as well as in the web of the stringer.

The allowable stress in one rivet in single shear is 3980 lbs. The total allowable stress = 6 × 3980 = 23900 lbs.

Efficiency with impact = 64.5 %

Efficiency without impact = 102 %

<u>Joists Under Flooring.</u>

These joists are composed of I Beams 7" @ 15# spaced 3'-0" C. to C. They rest directly on the top of the floor beam.

The dead load consists of the weight of the joist plus the weight of the plank flooring making a total of 50 lbs per lin. ft.

The live load consists of a concentrated load of 30000 lbs distributed over two axles 8 ft. centers and 5 ft guage, or a uniform load of 90 #/□', whichever gives the greater bending moment.

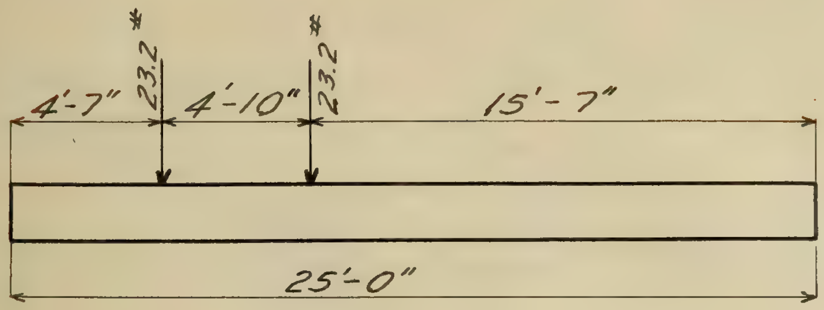
Allowable fibre stress = 16000 #/□"

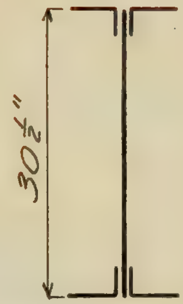
Section Modulus = 10.4 in³

Maximum Bending Mo = 228 000 in-lbs

Efficiency = 70 %

Floorbeams





Web 30" x $\frac{5}{16}$"
4 Ls 5" x 3" x $\frac{3}{8}$"
Eff. depth = 29.1"
Net Flange A = 6.14 □"

The floorbeams are made up of a web plate 30" x $\frac{5}{16}$" and 4 Ls 5" x 3" x 3/8". The length between end supports is 25'-0". The rivet spacing in the flange angles is 3".

The dead load is composed of the weights of the floor beam, stringers, and flooring. The live load is the maximum floorbeam reaction as shown in the above sketch.

1/8 of the area of the web is assumed to resist bending as part of the flange.

Total net area 4 Ls + $\frac{1}{8}$ web = 6.14 sq. in.

Allowable stress in fibres = 16 000 lbs/sq. in.

Total allowable bending mo. = 2 860 000 in lbs

Area of web 30" x $\frac{5}{16}$" = 9.27 sq. in

Allowable shear = 10 000 lbs/sq. in

Total allowable shear = 92 700 lbs.

The effeciencies are as follows.-

Maximum Bending Moment		Efficiency	
With Impact	Without Impact	With Impact	Without Impact.
4 278 000	2748000	66.8	108.0

Maximum Shear		Efficiency	
With Impact	Without Impact	With Impact	Without Impact.
59.0	37.9	157	245

Connections

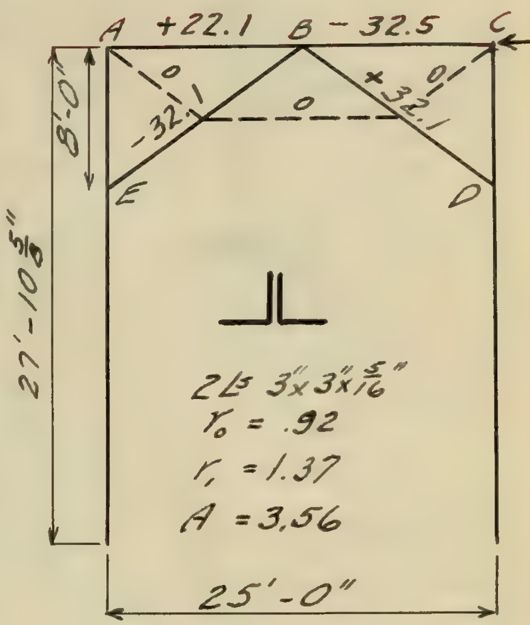
The connection is made by means of 6" x 3½" x ⅜" Ls and 12 shop rivets ¾" diameter to the intermediate posts and hip verticals. The shear in the rivets governs.

Allowable single shear ¾" rivet = 5300
Total allowable stress 12 rivets = 63600
Total Max Shear with impact = 59.0
Efficiency with impact = 108%
Total Max Shear without impact = 37.9
Efficiency without impact = 163%

Rivet Spacing.

Actual rivet spacing = 3 inches
Spacing required with impact = 2.6 inches
Spacing required without impact = 3.9 inches

Portals



All members of the portals are made up of 2 Ls $3'' \times 3'' \times \frac{5}{16}''$ placed back to back with $\frac{5}{16}''$ spreading rings between them. The wind load carried by the portals is 150 lbs per lineal foot of truss.

The allowable tension is 20000 #/□"

The allowable compression is $1.25(16000 - 70\frac{l}{r})$ #/□"

No allowance is made for reversals in stress as none occurs during the passing of any train.

The efficiencies are as follows.

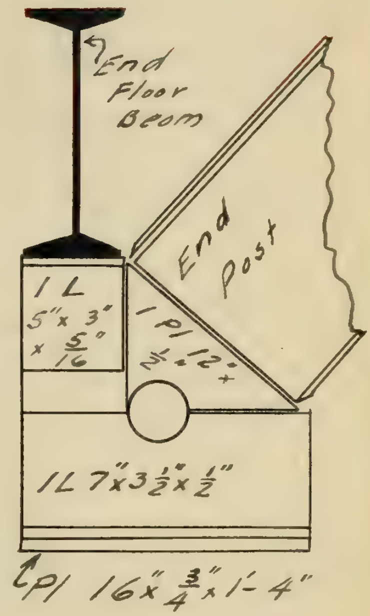
Tension.

Member	All. Stress	Actual. Str	Efficiency
AB	60.2	+22.1	272
BD	60.2	+32.1	188

Compression

Member	All. Stress	Actual Str.	Efficiency.
BC	16.7	-32.5	51
EB	41.2	-32.1	128

Pedestals



Each pedestal is made up of 2 Pls 16"x $\frac{1}{2}$"x 1'- 3" and 2 Ls 7"x 3$\frac{1}{2}$"x $\frac{1}{2}$" riveted together and a base plate 16"x $\frac{1}{2}$"x 1'-10" riveted to the Ls. The end floor beam rests directly on top of the pedestal and transfers all its load to the pedestal.

The allowable pressure on sandstone masonry is 400 lbs per sq. in.

The allowable bearing on the pin at L_0 is 24000 lbs. per sq. in.

Pin at L_0 is 4$\frac{1}{2}$" diameter. Allowable bearing = $4\frac{1}{2} \times (\frac{1}{2}+\frac{1}{2}) \times 24.000 =$ 108 000 lbs.

Allowable bearing on masonry = $16 \times 22 \times 400 =$ 140 800 lbs.

Efficiencies for pin are as follows.

Right Truss.

Max. Bearing		Efficiency	
With Imp.	Without Imp.	With Imp.	Without Imp.
162.0	122.0	66.6	88.5

Left Truss

Max Bearing		Efficiency	
With Imp.	Without Imp.	With Imp.	Without Imp.
87.0	71.2	124	152

The efficiences for the masonry plates are as follows.

Right Truss

Max. Bearing		Efficiency	
With Imp.	Without Imp.	With Imp.	Without Imp.
199.0	145.5	70.6	97.0

Left Truss

Max Bearing		Efficiency	
With Imp.	Without Imp.	With Imp.	Without Imp.
124.0	94.7	113	149

Rollers.

The rollers are so badly rusted as to be worthless. Under the Right truss they have been removed altogether and the pedestal slides on a plank, during expansion or contraction. Those under the Left truss are a hinderance rather than a help to the bridge.

Even though the rollers were in good condition they would be too small as 4" rollers are required while these were only about 3" in diameter when new.

Pins

The pins at L_0, L_4, U_1, and U_4 only, will be investigated as these pins govern the sizes to be used throughout the whole structure.

Allowable fiber stress in bending = 24000 #/□"
Allowable bearing stress = 24000 #/□"
Allowable shearing stress = 12000 #/□"

The efficiencies in bending are as follows.-

Right Truss

Pin.	Diam.	Max. B. Moment.		Efficiency	
		With Imp.	Without Imp.	With Imp.	Without Imp.
L_0	$4\frac{1}{2}$"	171000	128000	125	168
L_4	4 "	347000	260000	43	59
U_1	$3\frac{1}{2}$"	207000	160000	49	63
U_4	3"	43900	27800	145	229

Left Truss.

Pin	Diam	Max. B. Moment		Efficiency	
		With Imp.	Without Imp.	With Imp.	Without Imp.
L_0	$4\frac{1}{2}$"	89500	73000	240	294
L_4	4 "	181500	147500	83	102
U_1	$3\frac{1}{2}$"	114000	92500	89	109
U_4	3 "	17100	10800	371	587

The efficiencies in bearing are as follows.-

(see next page)

Right Truss.

Pin.	Bearing Area.	Maximum Stress		Efficiency	
		With Imp.	Without Imp.	With Imp.	Without Imp.
L_0	7.74	204.1	154.1	91.0	121.0
L_4	11.25	277.8	207.8	97.1	130.0
U_1	7.80	225.9	166.9	83.0	112.0
U_4	3.94	34.6	22.0	273.0	430.0

Left Truss.

Pin	Bearing Area.	Maximum Stress		Efficiency	
		With Imp.	Without Imp.	With Imp.	Without Imp.
L_0	7.74	109.3	89.9	170	208
L_4	11.25	145.1	117.9	186	229
U_1	7.80	114.0	91.1	164	205
U_4	3.94	17.1	10.8	560	875

The efficiencies in shear are as follows.

Right Truss.

Pin	Area.	Maximum Shear		Efficiency	
		With Imp.	Without Imp.	With Imp.	Without Imp.
L_0	15.90	204.1	154.1	94.0	124.0
L_4	12.57	277.8	207.8	54.5	72.7
U_1	9.62	144.9	106.9	80.0	108.0
U_4	7.07	43.9	27.8	193.0	305.0

Left Truss.

Pin	Area.	Maximum Shear		Efficiency	
		With Imp.	Without Imp.	With Imp.	Without Imp.
L_0	15.90	109.3	89.9	175	213
L_4	12.57	145.1	117.9	104	127.
U_1	9.62	76.4	61.6	152	187
U_4	7.07	17.1	10.8	495	780

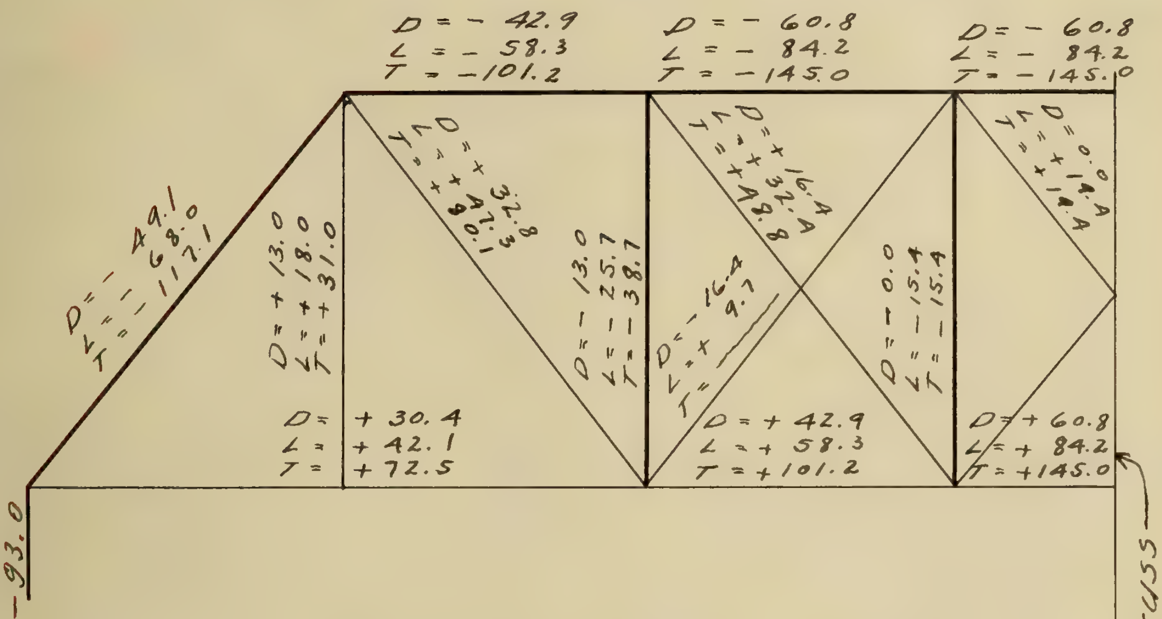
Part IV.

Recommendations.

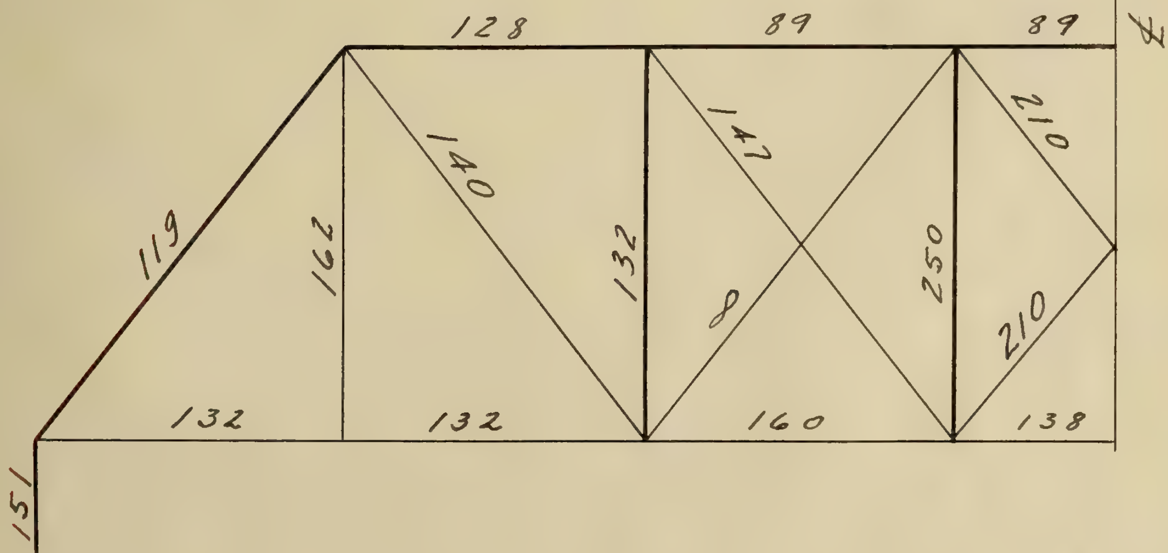
By referring to the table of efficiencies it is plainly evident that the bridge is too weak to carry the existing interurban traffic with safety. Even by moving the track to the ℄ of the bridge the desired efficiencies can not be obtained. Therefore, no interurban cars should be allowed on the bridge. However, the bridge is sufficiently strong to act as an ordinary highway bridge and on this account it is not recommended that the structure be removed altogether. The diagram on the next page shows the stresses and efficiencies obtained when there is a live load of 86 lbs. per. sq. ft. on the floor. This is the live load required by Ostrup's specifications. (Art. 60)

STRESSES AND EFFICIENCIES FOR HIGHWAY TRAFFIC ONLY

STRESSES IN TRUSSES



EFFICIENCIES OF MEMBERS



There are several details such as the pedestals, rollers and lateral bracing, which are in very poor condition and should be replaced by new members of the same design. There are no anchor bolts in any of the pedestals or masonry plates and many of the rivets are loose. These should all be replaced by new ones.

The south abutment is split vertically from top to bottom but might be used if the bridge carried highway traffic only. It would be difficult to repair this defect without building a new abutment.

The structure has not been painted for a long time but is not rusted badly enough to cause any trouble. It should be thoroughly scraped and painted with two coats of good paint.

The summary of the recommendations is as follows.-

1. The railroad tracks should be removed and no electric cars should ever be allowed on the bridge.

2. All pedestals should be replaced by new ones of the same design.
3. New Rollers 4 inches in diameter should be placed under the pedestals at the north end of the bridge.
4. Anchor bolts $1\frac{1}{4}" \times 12"$ should be placed in all masonry plates.
5. All rivets should be tested for tightness and all found loose should be replaced by new ones.
6. The south abutment should be put in as good condition as possible.
7. The whole structure should be scraped and painted with two (2) coats of good paint.

End.